Stagnation Point Heat Transfer with Gas Injection Cooling

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While ablation is an effective means of reducing the heat flux level reaching the vehicle structure, the influence of the ablation products, which can include both gas-phase species and solid particles, on the flow around a planetary entry vehicle is not well understood. Although charring ablators have been extensively used, there is considerable difficulty in modeling the material behavior, owing to the multiplicity of physical phenomena, and their potentially non-linear interaction.

The phenomenon of gas injection in the boundary layer (and its degree of nonequilibrium) around a test article remains so far ill studied in high enthalpy plasma flows. Simplifying assumptions are often invoked and experimental correlations used, but the underlying "real physics" is still poorly understood. The present paper deals with an experimental study of the stagnation point heat transfer to a fully catalytic (copper) cooled surface with gas injection under subsonic aerothermal tests conditions, conducted by the 1.2 MW VKI Plasmatron.

The newly developed heat flux probe with a gas injection system combined with steady-state water-cooled calorimeter has been successfully tested and exploited for heat transfer measurements. The probe surfaces had up to 53 holes for gas injection, the total square of the holes reached 2 % of the calorimeter front face square. The aerothermal tests have been performed in subsonic high-enthalpy air jets at the generator anode power between 130 and 210 kW. The static pressure was altered in the range 35-250 hPa. The heat transfer has been studied in the stagnation point configuration for a 50 mm diameter Euromodel. Different gases (air, nitrogen, carbon dioxide and argon) were injected into the boundary layer in the mass flow range 0-0.4 g/s. In the paper the results of measurements of the stagnation point heat transfer rates are reported.

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